

Impact-generated Hydrothermal Systems: Potential Sites for Pre-biotic Chemistry and Life on Early Earth and Mars

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Geologic and biologic conditions during the Hadean and early Archean were affected, if not dominated, by a flurry of impact cratering events. The lunar record suggests the Earth was resurfaced by >20,000 impact events that produced craters >20 km in diameter, ~40 of which were ≥ 1000 km diameter [e.g., 1]. The impacts would have severely shock- and thermally-metamorphosed existing crust and caused severe environmental changes [2], possibly exterminating any extant life or inhibiting its origin [3,4].

However, the impact events would have also created vast subsurface hydrothermal systems that may have been crucibles for pre-biotic chemistry and habitats for the early evolution of life. Our computer simulations indicate that even a moderately-sized 200 km diameter crater on Earth can produce a hydrothermal system that spans the entire diameter of the crater and reaches depths of several kilometers, consistent with geological observations at impact sites. Hydrothermal activity may persist for ~1 Ma, providing ample time for colonization by thermophilic organisms. Likewise, impact-generated hydrothermal systems on early Mars may have persisted for 50,000 to 700,000 years beneath complex craters up to 200 km in diameter.

References: [1] Kring & Cohen, *JGR* 107(E2), 4.1-4.6. [2] Zahnle and Sleep, in *Comets & the Origin & Evolution of Life*, 175-208, 1997. [3] Maher & Stevenson, *Nature* 331, 612-614, 1988. [4] Chyba, *Geochim. Cosmochim. Acta* 57, 3351-3358.